LAMINATED ROOT ROT

IDAHO DEPARTMENT OF LANDS

State Forester Forum

Root diseases are by far the most damaging type of native forest disease in northern Idaho. They are also the most difficult to manage. Infected trees suffer reduced growth, mortality, and increased susceptibility to bark beetle attack. At the stand-level root diseases reduce timber volume and stocking, alter the rate and direction of forest succession, and interfere with short- and long-term forest management objectives. Root diseases are caused by fungi that infect and decay tree roots, causing a loss of both root system function and structure. Loss of root function gradually weakens and kills trees. Loss of root structure results in windthrow of live trees and accelerated collapse of dead trees.

The most important root diseases in Idaho are laminated root rot, Armillaria root disease, and annosus root disease. Any combination of the fungi that cause these diseases, referred to as "root disease complexes", may be found acting separately in the same stand or even on the same tree. Laminated root rot, caused by the fungus *Phellinus weirii*, can be found across northern Idaho with Douglas-fir and true firs. The disease is not known to occur in southern Idaho.

Susceptibility to Laminated Root Rot

- Highly susceptible: Douglas-fir and grand fir.
- Moderately susceptible: Western redcedar, western hemlock, and subalpine fir.
- Least susceptible: Western larch and pines.
- Immune: Hardwoods.

Key Point: Variation in host resistance to laminated root rot is not expressed before age 15-20 or later.

Biology

Phellinus weirii produces spores from fruiting bodies that form infrequently on the underside of infected downed trees and upturned roots. Each "individual" of the fungus resulting from successful spore infection is called a clone, or more accurately a "genet". The substrate on which spores begin new infections and the conditions under which this occurs are poorly understood. Research has shown, however, relatively few genets exist across a given piece of ground, and therefore spore-spread is considered a rare event and not considered important in disease management.

Once an infection begins, tree-to-tree spread of *P. weirii* occurs via root contacts or grafts; the fungus does not grow freely through the soil environment. Living roots are believed necessary for spread of the fungus. When *P. weirii* infects a root it grows along the root surface, eventually penetrating the bark to the cambium and initiating decay. The early stages of decay, called incipient decay, cause a staining on the stump surface which is readily visible when infected trees are cut (Figure 1).

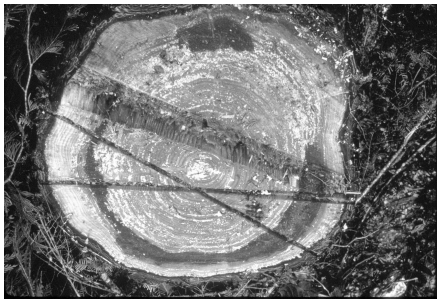

Figure 1. Staining on fresh stump surface due to incipient decay.

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The fungus kills living tissue of infected trees but is known to survive for over 50-years in large roots and stumps of dead trees; smaller roots maintain the fungus for considerably less time. It is this long-term presence of inoculum, or fungus-infected woody tissue, which makes root disease management difficult. Roots of uninfected trees contact the infected roots of a living or dead tree, the fungus grows onto the uninfected root, and the disease is perpetuated. The ability to occupy a site for decades and cause disease in consecutive forest generations is why root disease is often referred to as a "disease of the site".

As root disease spreads from tree-to-tree it can form roughly circular centers of infection where many, but most often not all, of the trees are symptomatic or dead, depending on stand structure and composition. These areas of concentrated damage are referred to as "root disease centers" (Figure 2).

Figure 2. Root disease center.

Laminated root rot spreads outward an average of about one foot per year and centers can expand to tens of acres. Numerous root disease centers caused by laminated root rot may be dispersed randomly throughout a stand. Not all diseased areas are delineated by an obvious root disease center. In some instances the disease occurs in a "diffuse" distribution where individual or small groups of trees are affected across the entire area where the fungus occurs.

Wildfire will have little effect on laminated root rot. Well-decayed root channels of trees killed by laminated root rot may burn out during a fire, but the overall impact of fire on underground inoculum will not be substantial. The main effect fire has on laminated root rot is the influence it has on long-term stand composition and thus the amount of damage that can occur; seral species promoted by fire, such as western larch and pines, are tolerant of laminated root rot.

Recognizing Root Disease in a Stand

Stand-level "signatures" can aid in identifying the presence of root disease. Root disease centers, or areas of concentrated mortality, are the most obvious (Figure 2). Variously-aged snags and trees with symptomatic crowns will be dispersed in and around such centers or diffusely throughout a stand. Death of susceptible species causes gaps in the overstory canopy which promote conifer regeneration - most often of mid- or late-successional, disease-susceptible species - or growth of brush. Brushfields can occupy such sites for decades until conifers regain a foothold. Small hardwood groves, such as aspen or birch, can be a clue that root disease is present because they are immune to laminated root rot.

Trees infected or killed by root disease lose structural support as large roots are decayed; when trees uproot these decayed roots break off near the root collar. The root collar, stubs of decayed roots, and attached soil that come from the ground when trees fall are referred to as "root wads" or "root balls" and are very typical of laminated root rot (Figure 3).

Figure 3. "Root ball" caused by laminated root rot.

Downed trees in root disease centers can be distinguished from windthrown trees by the pattern they form. Windthrown trees that go down in a storm will fall, for the most part, in the same direction. Trees that fall due to decay caused by laminated root rot will fall at different times, with or without wind. Therefore downed trees in root disease centers often lay in all directions.

Bark beetles and root diseases are closely associated. The reduction in tree vigor and changes in tree physiology caused by root disease can make them more attractive to bark beetles. Larger trees experiencing infection over longer periods are more likely to be attacked. When searching for reasons why trees have died a diagnosis of bark beetles should be followed by an examination for root disease. This may be difficult, however, as beetles often kill trees while evidence of root disease is still subtle.

Identifying Laminated Root Rot

Descriptions and images of root disease-symptomatic trees can be found in "A Field Guide to Diseases & Insect Pests of Northern and Central Rocky Mountain Conifers". Foresters and landowners should always have this guide on hand when diagnosing forest insect and disease problems.

Root diseases cause gradual loss of root function and structure, an effect reflected in the type of symptoms which develop in infected trees
(Figure 4). These include:

- reduced terminal and lateral growth over a span of several to many years;
- thinning of the crown, often proceeding from the bottom up and inside out;
- off-color or chlorotic (yellowing) foliage;
- slight to heavy resinosus (pitch-streaming) around the base of the tree;
- flushes of small cones, referred to as "stress cones", which can persist after the tree dies; and/or wood decay with unique features characteristic of each root disease.

Figure 4. Typical root disease crown symptoms.

The size of an infected tree will affect expression of disease symptoms. Larger trees, with more expansive root systems, will develop symptoms more gradually than a sapling or seedling, which may succumb relatively quickly and develop few if any crown symptoms. Large trees may not show symptoms for years after infection until much of their root system is compromised. Therefore any disease-susceptible tree within 30-feet of an infected tree should be considered infected.

> *Key point*: A general rule-of-thumb is only about half of all root disease-infected trees can be detected by above-ground symptoms at any one time.

Evidence of the fungus itself may be found on the exterior of roots of live, symptomatic trees. This superficial fungal growth of *P. weirii* is known as

"ectotrophic mycelia" and is how the fungus spreads along roots before penetrating into the

Figure 5. "Ectotrophic mycelia" of *Phellinus weirii* on surface of infected root.

root interior (Figure 5).

To examine for this scrape away the soil from lateral roots adjacent to the base of the suspect tree and look for a grey-white to tawny to light purple fungal mycelia around the entire outer surface.

If you suspect laminated root rot a final diagnosis

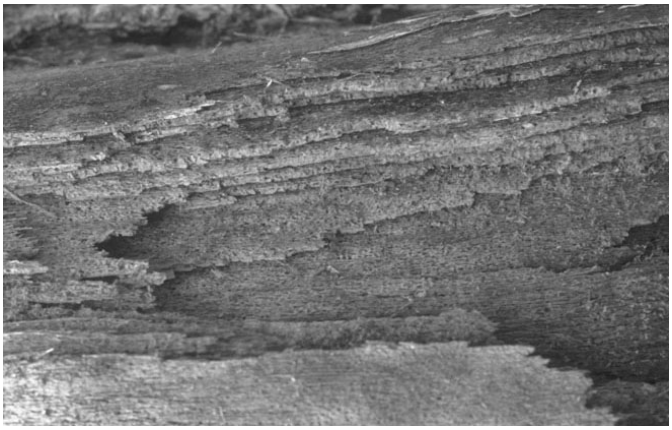

Figure 6. Advanced decay caused by *Phellinus weirii*.

can be made from the characteristic, advanced decay in the roots and butts of infected trees (Figure 6).

Advanced decay, most readily evident on windthrown trees with broken roots or trees broken off near the ground, separates easily between the annual rings – thus the name "laminated root rot". The wood is heavily pitted on both sides by pits about 0.5 millimeter wide and 1 millimeter long. Close examination of this decay with a 10x or stronger hand lens should reveal setal hyphae (Figure 7), a type of fungal structure appearing like tiny, reddish whiskers about 0.3 millimeters long; setal hyphae are diagnostic for *P. weirii*.

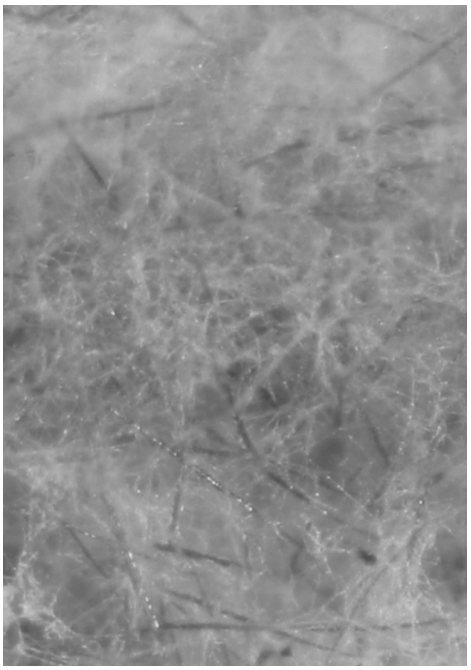

Figure 7. "Setal hyphae" of *Phellinus weirii*.

Management

Root disease management should be site-specific and based on stand management objectives, the root disease or disease complex present, estimates of root disease severity, stand structure and composition, and stand history. Management of root disease is not a "one-size-fits-all" proposition so the following should be viewed as guidelines.

Determine objectives: Formulate management objectives for the stand in question. A timber production objective requires very careful

consideration of root disease; other objectives may not.

Estimate "root disease severity": An estimate of root disease severity (Table 1) provides a "snapshot" of current root disease impact and mortality rates, as well as the best estimate of future mortality and the trajectory of stand structure and composition. Root disease severity, and thus management, can vary throughout a stand.

Regeneration harvest: If root disease is severe and few disease-resistant species are available to select as leave-trees, and your objective is timber production, then the best option from a disease management standpoint is to clearcut the stand and start over.

> *Key Point*: Salvaging dead and dying trees on root disease centers can capture volume before it becomes unmerchantable, but due to the biology of the fungi that cause root disease, salvage **does not** slow mortality or halt spread of disease.

Stand establishment: Trees planted on sites with laminated root rot need to be disease-tolerant. Western larch or pine species would be good choices, depending on the site; Douglas-fir and grand fir will be severely damaged. Ensure quality-control during planting since "J-rooted" seedlings of any species are readily damaged by root disease.

> *Key Point*: Managing for disease-tolerant species is usually the most effective and cost-efficient means of overcoming root disease.

Precommercial stands: Many stands composed of disease-susceptible species have been established, either by planting or natural regeneration, in the presence of moderate to severe root disease. Such stands often show few symptoms of disease till 15-20 years later, or more, when roots of growing trees have contacted inoculum from the previous stand and numerous pockets of laminated root rot begin to appear. In such instances, whether precommerical thinning has been done or not, the best option may be to destroy the current stand and start over with disease-tolerant species; a better yield will almost certainly result.

If a young stand has extensive root disease mortality but includes well-distributed, disease-tolerant species then delay thinning at least several years to allow the root disease time to "select" which trees will survive before you invest in thinning. If thinning is eventually done leave a higher-than-normal stocking of disease-tolerant trees in anticipation that more will die as the stand matures. In many instances, however, root disease will reduce stocking to where only "clumps" may need thinning.

Young stands with a "light" root disease severity rating can be thinned without delay, but emphasize selection of disease-tolerant species over maintaining uniform spacing.

> *Key point*: Precommercial thinning that favors and promotes disease-tolerant species will aid root disease management and protect your investment in regeneration and thinning.

Commercial stands: Thinning is not recommended on ground impacted by laminated root rot if the most susceptible species, Douglas-fir and grand fir, will make up more than 30% of the leave-trees. Many of the disease-susceptible trees will already be infected, even if not currently displaying crown symptoms, and often die within a few years of thinning.

A landowner may be sorely tempted to thin a root-diseased stand, leaving the best-looking Douglas-fir and grand fir, with the expectation these trees will experience "increased vigor" and thus resist root disease. The evidence is not clear at this time whether thinning accelerates damage in such a situation, but it is clear that ***mortality rates will not decrease in disease-susceptible species***.

Key point: Laminated root rot can infect and kill susceptible species of any age and size, regardless of perceived or actual vigor.

Management of stands impacted by laminated root rot should emphasize promotion and maintenance of seral species. Silvicultural approaches that achieve this objective are recommended even for stands with a light root disease severity rating. Managing for disease-susceptible species, and harvesting the disease tolerant species, will result in ever-increasing amounts of disease inoculum and only serve to worsen root disease severity and reduce management options for the next rotation.

Key point: Long-term root disease management should take a "***do no harm***" approach; maintain and promote mature seral species and their natural regeneration, plant with disease-tolerant species, and take no actions which will increase inoculum.

"Buffer removal" is one tool suggested for management of laminated root rot when disease center boundaries are discrete and final harvest is more than 10 years off. The concept behind buffer removal is to eliminate the live-root pathways among susceptible species believed necessary for the fungus to expand into non-infected portions of a stand. Various approaches have been described, ranging from removal of all trees for approximately 50-65 feet around infection centers, to removal of only the disease-susceptible species. Either way all symptomatic trees from within the center should also be removed. If all trees have been removed from the infection center and buffer, and if the area is large enough, consideration can be given to planting with disease-tolerant species in order to utilize the site and prevent occupation by disease-susceptible conifers or brush.

Key point: The biggest problem with "buffer removal" in northern Idaho forests is few disease centers are well-delineated or well-separated from other root disease centers. This treatment would most likely be difficult to apply successfully.

Inoculum removal: Using heavy machinery to remove stumps and large roots from the ground in root-diseased stands can reduce short-term damage in the subsequent stand due to reduction in inoculum, but long-term results are mixed. Against laminated root rot it has been practiced mainly on highly-productive, coastal Douglas-fir sites. Inoculum removal requires ***very careful*** consideration based on slope, soil moisture and type, and site productivity. While it is not considered economically practical in commercial forests of Idaho, private landowners with small parcels of land impacted by root disease might consider this option under the right circumstances.

Fertilization: At this time there is no evidence that fertilization reduces the incidence or severity of laminated root rot.

Table 1. Root disease severity.

Root Disease Severity	Range of Conditions
Light	Includes stands with no evidence of root disease, stands with no mortality but numerous trees displaying symptoms, and stands with *up to 20% canopy reduction due to root disease mortality*.
Moderate	Includes stands with *20-75% canopy reduction due to root disease mortality*. At the lower end of this range there will also be many trees with root disease symptoms, while at the upper end much of the remaining overstory canopy consists of disease-tolerant species. Moderate severity stands are changing quickly; mortality rates are high.
Severe	Includes stands with *at least 75% canopy reduction due to root disease mortality*. These stands are usually composed of only the most susceptible species. At the lower end of this range only a few susceptible overstory trees remain although there may be densely stocked, susceptible regeneration; at the upper end no susceptible species remain in the overstory. Mortality rates in this category will begin to slow because most susceptible species are already dead.

Required acknowledgements:

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